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magnetostrictive material imparting stress to a piezoelectric material to produce a detectable voltage that is a sine wave form and alternating at a frequency which is indicative of rotation speed of the motor.

REMARKS

In the Office Action dated May 16, the Examiner rejected Claims 2-14, 17-22 and 30-33 for obviousness and/or indefiniteness. With the entry of the present Amendment, Claim 2 has been cancelled, and Claims 3, 4, 5, 7, 9, 17, 18, 19, and 20 have been amended to alternatively characterize the invention. The remaining claims, Claims 15, 16, and 23-29, have been withdrawn from consideration as directed to a non-elected invention.

The Examiner objected to the Title of the Invention and to the Abstract as not sufficiently descriptive of the present invention. Accordingly, the Title of the Invention and the Abstract have been amended to be more indicative of the invention as claimed.

No new matter has been added by this Amendment.

Turning now to the indefiniteness rejection, the Examiner rejected Claims 2-5, 13, 17-22, and 30-32 under 35 U.S.C. §112, second paragraph, for failing to particularly point out and distinctly claim the subject matter which applicant regards as his invention.

With respect to the rejection of Claims 2 and 17, Claim 2 has been cancelled and Claim 17 has been amended to remove the term "about."

With respect to Claim 5, this claim has been amended to clarify the high-impedance readout circuit and its relation to the other elements of the device.

With respect to Claim 13, it is respectfully submitted that the term "matrix" in this context would be understood by one of ordinary skill in the art as having its broadest ordinary meaning of a substance which surrounds something else–specifically a piezoelectric rod or fiber. As defined in the American Heritage Dictionary, 4th Ed. (2000), for example, a matrix is broadly defined as "[a] situation or *surrounding substance* within which something else originates, develops, or is contained." (Emphasis added). Moreover, Claim 13 itself further supports this interpretation, as Claim 13 recites that the piezoelectric rod or fiber "is surrounded by" the

magnetostrictive matrix material. Accordingly, it is requested that the indefiniteness rejection be withdrawn with respect to Claim 13.

Regarding Claim 30, the term "connected electronically in parallel" is not indefinite, as the skilled artisan would clearly understand that, in electronics, multiple elements are connected in parallel when all of the positive poles or terminals of the elements are connected to a first conductor, and all of the negative poles or terminals are connected to a second conductor (as distinguished from elements being connected end to end to form a single current path–i.e. "in series"). Accordingly, it is requested that the indefiniteness rejection be withdrawn with respect to Claim 30.

With respect to Claims 18 and 19, these claims have been amended to more clearly recite the function and relationship of the circuit to the other elements of the device.

Also, Claim 20 has been amended to alternatively recite the motion speed detection system, which comprises a magnetic wheel that induces a changing magnetic field. Regarding the Examiner's assertion that it is unclear "how" the wheel induces a changing magnetic field, it is submitted that the applicants are entitled to claim this element generically, and are not required by §112 second paragraph to recite a specific type of magnetic wheel and how it functions. The present specification provides multiple examples of a magnetic wheel inducing a changing magnetic field, as shown and described in connection with Figs. 13, 15, 16, 17, and 18, for instance. Thus, it is believed that the indefiniteness rejection with respect to Claim 20 is overcome.

Turning now to the obviousness rejections, the Examiner rejected all claims under 35 U.S.C. §103 as being unpatentable over GB 2,188,157, to Oetzmann.

Claim 3 has been amended to recite a magnetic field sensor comprising a multilayer structure consisting essentially of two layers of magnetostrictive material sandwiching one layer of piezoelectric material, the two layers of magnetostrictive material arranged to strain in the presence of an alternating magnetic field, and impart stress to the piezoelectric layer to produce a detectable voltage signal in the piezoelectric layer; and a circuit coupled to the piezoelectric layer for detecting the voltage signal, wherein during operation the magnetic field sensor does not consume any external electrical power.

Claim 4 has been amended to recite a similar magnetic field sensor wherein the multilayer structure consists essentially of two layers of piezoelectric material sandwiching one layer of magnetostrictive material, the layer of magnetostrictive material being arranged to strain in the presence of an alternating magnetic field and impart stress to the piezoelectric layers to produce a detectable voltage signal in the piezoelectric layers, and wherein during operation the magnetic field sensor does not consume any external electrical power.

Also, Claim 17 has been amended to recite a magnetic field sensor comprising a multilayer structure consisting essentially of two layers of a first material sandwiching one layer of a second material, wherein the first material comprises one of a magnetostrictive material and a piezoelectric material, and the second layer comprises the other one of a magnetostrictive material and a piezoelectric material, wherein during operation the magnetic field sensor does not consume any electrical power.

Each of these claims are distinguishable from the cited Oetzmann reference in that they each relate to *passive* devices, in which the multilayer piezoelectric/magnetostrictive sensing element does not consume any external electrical power. Oetzmann, on the other hand, actually *teaches away* from this design by teaching that a passive magnetic field sensor comprising a layer of piezoelectric material between two layers of magnetostrictive material is noisy and unstable in operation.

In fact, the Oetzmann reference directs one of ordinary skill to employ a *non-passive* sensor which includes a power-consuming electromagnet as an essential component. In particular, the Oetzmann patent teaches that a "simple dc sensor arrangement" (p. 1, line121) having a magnetostrictive member secured to a piezoelectric member, with no power-consuming electromagnet, suffers from a number of critical deficiencies, such as built-up charge of the surface of the piezoelectric member, thermal expansion between the members, and electron drift in the piezoelectric member. These create a parasitic potential difference in addition to the potential difference from the applied magnetic field, "and hence result in the sensor being *noisy and unstable in operation*." (p. 1, lines 17-24). Accordingly, Oetzmann teaches, "[i]t is an object of the present invention to provide a magnetic sensor in which the above disadvantages are overcome." (p. 1, lines 25-27).

The invention described by Oetzmann utilizes an electromagnet arranged to apply an alternating magnetic field to the sensor. (p. 1, lines 38-39). As shown and described in connection with Fig. 3, the sensor 1,2,3 is placed within a solenoid 4, and in operation, an alternating current is supplied to the solenoid 4 from a source 5. Oetzmann explicitly teaches away from the *passive* (i.e. non-power consuming) magnetic sensors of present invention, and instead directs the ordinarily skilled artisan to adopt a non-passive design in which a power-consuming electromagnet is an essential component of the magnetic sensor. See, e.g., Bausch & Lomb, Inc. v. Barnes-Hind/Hydrocurve, Inc., 230 U.S.P.Q. 416, 419-20 (Fed. Cir. 1986) (district court's reliance on isolated portion of reference was impermissible hindsight obviousness analysis, where complete reading of reference makes it clear that discussion of laser etching of contact lenses was merely to point out disadvantages of this method and to highlight advantages of different method, and where reference as a whole taught away from claimed laser etching method).

The present inventors, on the other hand, have discovered that by optimizing the material properties and structure design of a magnetic field sensor utilizing piezoelectric and magnetostrictive materials, it is possible to produce multilayer *passive* magnetic field sensors for a variety of magnetic field sensing applications, in contrast to what was taught in the art. The advantages of such devices include, for instance, high field sensitivity, wide dynamic range up to several thousand Oersted, low cost in manufacturing, and no need for external power. (See Specification at p. 3, line 18 through p.4, line 19).

Accordingly, it is believed the present amendment places independent Claims 3, 4, and 17 into condition for allowance. Reconsideration is respectfully requested.

With respect to the remaining claims, Claims 5-14, 18-22, and 30-33, it is believed that the Examiner's obvious rejections are overcome for the reasons set forth below.

The Examiner's rejection of Claim 5 is overcome because the Examiner asserts that the prior art teaches that the sensitivity of the sensor is dependent on the area of the layers. Claim 5 actually recites that the sensitivity is *independent* of the area of the sensor, exactly the opposite of what the Examiner asserts is taught by the prior art. Accordingly, it is believed that the rejection of Claim 5 is overcome.

Claim 6 recites a magnetic field sensor comprising at least one layer of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to at least one layer of piezoelectric material to produce a detectable voltage, wherein the sensor is supported as a cantilever in which one end of the sensor is allowed to strain freely to thereby increase the sensitivity. The Examiner rejected this claim for obviousness, stating that "supporting the sensor as a cantilever is a matter of design selection, since it has been held that the provision of adjustability/suitability, where needed, involves only routine skill in the art."

The only prior art reference cited against Claim 6 or any other claim in this application is the Oetzmann reference. Where, as here, an obviousness rejection is based on a single prior art reference, there must still be a showing of a suggestion or motivation to modify the teachings of that reference to produce what is claimed by the applicant. In re Kotzab, 55 U.S.P.Q.2d 1313, 1316-17 (Fed. Cir. 2000). The teaching, suggestion, or motivation can be explicit or implicit, but in any case the Examiner must provide particular findings related thereto. Id. As the Federal Circuit has stated in this context, "broad conclusory statements standing alone are not 'evidence'" of such a suggestion or motivation. Id.

There is no teaching, suggestion, or motivation within the cited Oetzmann reference itself to provide a magnetic sensor as recited in Claim 6, wherein the sensor is supported as a cantilever in which one end of the sensor is allowed to strain freely to thereby increase the sensitivity. Moreover, the Examiner has failed to make a showing of any suggestion or motivation to modify the teachings of the cited Oetzmann patent to produce the invention as claimed. The Examiner's conclusory statement that the particular sensor of Claim 6 is a "design selection" is not a substitute for the required showing of a suggestion or motivation to produce what is now claimed. See, e.g., In re Gordon, 221 U.S.P.Q. 1125, 1127 (Fed. Cir. 1984) ("The mere fact that the prior art could be so modified [to produce the claimed invention] would not have made the modification obvious unless the prior art suggested the desirability of the modification"). As the Examiner has shown no suggestion or motivation to make the invention as claimed, the Examiner has failed to make a *prima facie* case of obviousness. It is therefore submitted that Claim 6 is allowable.

Independent Claim 7 recites a magnetic field sensor comprising a substrate of magnetostrictive material and a thin layer of piezoelectric material over the substrate, the

magnetostrictive substrate straining under the influence of a magnetic field and imparting stress to the layer of piezoelectric material to produce a detectable voltage. Independent Claim 9 recites a magnetic field sensor comprising a substrate of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to at least one patterned stripe of piezoelectric material to produce a detectable voltage.

As described in the present Specification at p. 11, line 5 through p. 6, line 18, for instance, the present invention relates in one aspect to magnetic sensors having a planar structure design having a magnetostrictive substrate. As shown in Figs. 3a and 3b, a material having magnetostrictive properties (preferably a ferrite) is used as a substrate, upon which is formed a thin layer of a piezoelectric material, preferably patterned stripes of a piezoelectric material. As described in the present application, this design is particularly advantageous for many applications, as the low-capacitance design allows for high frequency applications. Also, the efficient two-layer structure allows for the use of thin-film processing techniques.

The Examiner did not specifically address either Claim 7 or Claim 9 in the Office Action, although the Examiner did state that "the shape of the piezoelectric or magnetostrictive (e.g. matrix, stripes, rod, etc.) material/layer...is considered a matter of design selection."

Again, applicant submits that the Examiner has not made the required showing of a suggestion of motivation to modify the prior art to produce what is now claimed. There is no teachings, suggestion, or motivation in Oetzmann to produce a magnetic field sensor as recited in Claims 7 or 9. Moreover, the Examiner failed to provide any showings or findings of a suggestion or motivation to produce what is claimed. Accordingly, it is believed that Claims 7 and 9, and their dependents, Claims 8 and 10-12, are allowable.

Claim 13 recites a magnetic field sensor comprising a matrix of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to at least one rod or fiber of piezoelectric material that is surrounded by the matrix to produce a detectable voltage. Claim 14 recites a magnetic field sensor comprising at least one rod or fiber of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to a matrix of piezoelectric material surrounding the at least one rod or fiber to produce a detectable voltage.

As described in the present Specification at p. 12, line 18 through p. 13 line 20, the present invention relates in one aspect to a magnetic field sensor having a fiber composite design.

As shown in Figs. 4a-4d, for instance, piezoelectric fibers or rods can be formed (via injection molding, for instance), and then packed with a matrix of a magnetostrictive powder. The array can then be sintered at an elevated temperature to produce a magnetic sensor device. In other embodiments, fibers or rods of magnetostrictive material can be packed in a piezoelectric matrix to provide a magnetic field sensor. The advantages of this matrix design include improved sensor performance due to increased interface area between piezoelectric and magnetostrictive materials, a larger piezoelectric voltage constant, and increased lengths of piezoelectric materials (resulting in lower capacitance for high-frequency operation). Moreover, the matrix sensor structure is extremely reliable and durable since the piezoelectric and magnetostrictive materials are bonded by sintering rather than adhesives, and the cylindrical interface between the materials can withstand more shear stress than in the case of a multi-layered laminate structure.

The Examiner did not specifically address any of the claims directed to the fiber composite structure (i.e. Claims 13-14 and 30-33), however the Examiner did state that "the shape of the piezoelectric or magnetostrictive (e.g., matrix, stripes, rod, etc.) material/layer...is considered a matter of design selection."

It is respectfully submitted that the above statement does not constitute the suggestion or motivation to produce the claimed invention necessary to sustain an obviousness rejection under 35 U.S.C. §103. There is no teaching or suggestion anywhere in the cited Oetzmann reference regarding a fiber composite magnetic sensor device as presently claimed. Moreover, the Examiner has not shown any suggestion or motivation to modify the prior art to produce what is claimed in Claims 13-14 and 30-33. Accordingly, it is believed that Claims 13-14 and 30-33 are allowable.

Claims 18 and 19, which are directed to magnetic field sensor arrays, are not specifically addressed in the Office Action. However, it is believed that the statement that the "use of multiple magnetic field sensors is considered a matter of design selection" is intended to apply to these claims. Applicants submit that the Examiner has not shown the required suggestion or motivation to produce the invention as claimed in Claims 18 and 19. Specifically, there is no teaching or suggestion in the cited Oetzmann patent regarding one-dimensional or multi-dimensional arrays of magnetic sensors having a readout circuit for detecting the voltage signal from each of the sensors. In addition, the Examiner has provided no suggestion or motivation to

modify the teachings of the prior art to make the invention as claimed, and therefore has not made a *prima facie* case of obviousness. Accordingly, Claims 18 and 19 should be allowed.

Claim 20 is directed to a motion speed detection system, comprising a magnetic wheel which produces a varying magnetic field as it rotates, and a sensor located near to the magnetic wheel comprising a magnetostrictive material that strains under the influence of the varying magnetic and imparts stress to a piezoelectric material to produce a detectable voltage that is a sine wave form and its frequency is indicative of rotation speed of the motor. Claim 20 was not specifically addressed in the obviousness section of Office Action, although it is believed that the discussion of a sensor device for rotary movement (see Office Action pp. 4-5) is intended to apply to this claim.

With respect to Claim 20, it is submitted that the Examiner has failed to make a *prima facie* case of obvious, as there is no teaching, suggestion, or motivation to produce the motion speed detection system as presently claimed. The Examiner concedes that Oetzmann does not teach a motion speed detection system using a magnetic field sensor. However, the Examiner argues that "it would have been obvious to one having ordinary skill in the art to use a magnetic field sensing device for *any intended purpose*." (Emphasis added). This is an incorrect statement of the law. As discussed above, there must always be a showing of a suggestion or motivation to modify the teachings of the prior art to produce the invention that is claimed. See In re Kotzab, 55 U.S.P.Q.2d at 1316-1317.

Moreover, it is unclear which "feature" of the claims the Examiner refers to as "a statement of an intended use and provides no patentable weight to the claims." It is believed that Claim 20 positively recites the elements of the claimed motion speed detection system, including the wheel mounted on the shaft and the magnetic sensor, and that the claim considered as a whole patentably defines over the prior art of record.

Accordingly, it is believed that Claim 20 and dependent Claims 21-22 should be allowed.

CONCLUSION

In view of the above amendments and remarks, it is believed that all claims are in condition for allowance, and it is respectfully requested that the application be passed to issue. If the Examiner feels that a telephone conference would expedite prosecution of this case, the Examiner is invited to call the undersigned at (978) 341-0036.

Respectfully submitted,

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MARKED UP VERSION OF AMENDMENTS

Specification Amendments Under 37 C.F.R. § 1.121(b)(1)(iii)

Please replace the existing Title of the Invention with the following new Title:

–Passive Magnetic Field Sensors Having Magnetostrictive and Piezoelectric Materials--

Replace the paragraph at page 27, lines 4 through 7 with the below paragraph marked up by way of bracketing and underlining to show the changes relative to the previous version of the paragraph.

-- Passive solid-state magnetic sensors [are based on the combination of magnetorestrictive materials and piezoelectric materials] <u>comprise a magnetostrictive material in contact with a piezoelectric material. The magnetostrictive material strains under the influence of an external magnetic field and imparts stress to the piezoelectric material to produce a detectable voltage signal indicative of the external field.</u> Sensors have applications in rotor speed detection, electrical current measurements, magnetic imaging, magnetic field detection, read heads, and MRAM, for example.--

Claim Amendments Under 37 C.F.R. § 1.121(c)(1)(ii)

3. (Amended) A magnetic field sensor [as described in Claim 2, wherein the sensor consists] <u>comprising:</u>

<u>a multilayer structure consisting</u> essentially of two layers of magnetostrictive material sandwiching one layer of piezoelectric material<u>, the two layers of magnetostrictive material arranged to strain in the presence of an alternating magnetic field, and impart stress to the piezoelectric layer to produce a detectable voltage signal in the piezoelectric layer; and</u>

a circuit coupled to the piezoelectric layer for detecting the voltage signal,wherein during operation the magnetic field sensor does not consume any external electrical power.

4. (Amended) A magnetic field sensor [as described in Claim 2, wherein the sensor consists] comprising:

a multilayer structure consisting essentially of two layers of piezoelectric material sandwiching one layer of magnetostrictive material, the layer of magnetostrictive material arranged to strain in the presence of an alternating magnetic field and impart stress to the piezoelectric layers to produce a detectable voltage signal in the piezoelectric layers; and

a circuit coupled to the piezoelectric layers for detecting the voltage signal, wherein during operation the magnetic field sensor does not consume any external electrical power .

5. (Amended) A magnetic field sensor as described in Claim [2] 3, wherein a sensitivity of the sensor is proportional to a thickness of the piezoelectric layer and substantially independent of an area of the sensor when the circuit comprises a high impedance readout circuit [is used].

7. (Amended) A magnetic field sensor comprising [at least one layer] a substrate of magnetostrictive material and a thin layer of piezoelectric material over the substrate, the magnetostrictive substrate [that strains] straining under the influence of a magnetic field and [imparts] imparting stress to [at least one] the layer of piezoelectric material to produce a detectable voltage[, wherein the magnetostrictive material forms a substrate].

9. (Amended) A magnetic field sensor comprising a substrate of magnetostrictive material that strains under the influence of a magnetic field and imparts stress to at least one patterned stripe of [electrically insulating] piezoelectric material on the substrate to produce a detectable voltage.

17. (Amended) An electromagnetic field sensor comprising: [about one]

a multilayer structure consisting essentially of two layers of a first material sandwiching one layer of a second material, wherein the first material comprises one of a

magnetostrictive material and a piezoelectric material, and the second layer comprises the other one of a magnetostrictive material and a piezoelectric material, the [layer of] magnetostrictive material [that strains] being arranged to strain under the influence of a magnetic field and [imparts] impart stress to [about one layer of] the piezoelectric material to produce a detectable voltage signal; and

a circuit coupled to the multilayer structure for detecting the voltage signal, wherein during operation the magnetic field sensor does not consume any external electrical power .

18. (Amended) A magnetic field sensor array, comprising: a one dimensional array of magnetic field sensors, each field sensor comprising layers of magnetostrictive and piezoelectric material, the magnetostrictive material straining under the influence of a magnetic field and imparting stress to the piezoelectric material to produce a detectable voltage signal; and a read-out circuit coupled to each sensor for detecting [a response] the voltage signal of each one of the magnetic field sensors.

19. (Amended) A magnetic field sensor array, comprising: a multi-dimensional array of magnetic field sensors, each field sensor comprising layers of magnetostrictive and piezoelectric material, the magnetostrictive material straining under the influence of a magnetic field and imparting stress to the piezoelectric material to produce a detectable voltage signal; and a read-out circuit coupled to each sensor for detecting [a response] the voltage signal of each one of the magnetic field sensors.

20. (Amended) A motion speed detection system, comprising a magnetic wheel mounted on a shaft of motor, the magnetic wheel arranged to produce a varying magnetic field near to the magnetic wheel as the wheel rotates on the shaft; and a sensor located near to the magnetic wheel comprising a magnetostrictive material that strains under the influence of [a changing] the varying magnetic field induced by rotation of the magnetic wheel, the magnetostrictive material imparting stress to a piezoelectric material to produce a detectable voltage that is a

sine wave form and [its] alternating at a frequency which is indicative of rotation speed of the motor.